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SHORTER ARTICLES AND DISCUSSION

A LITERARY NOTE ON MENDEL'S LAW

THE ever-increasing extension of the doctrine of Mendelism brings it year by year to the attention of a widening circle of general readers. Its application in the field of eugenics has aroused a popular desire for a further knowledge of the now famous principles of Mendel. Owing to the relative inaccessibility of Mendel's original publication the exact terms in which he formulated his conclusions have not been readily available. To meet in some measure this lack of ready reference the following brief, synoptic statement of the fundamental principles of Mendel is here presented in his own words, together with certain collateral notes that may be of value to students of this important law.

The general term "Mendel's Law" is usually applied to several complex principles discovered by Gregor Mendel while studying inheritance in certain plant hybrids. Various other designations, however, appear in the literature, *e. g.*, Mendel's "Law of Heredity,"[1] "Law of Inheritance,"[2] "Laws of Alternative Inheritance,"[3] and "Law of Varietal Hybrids."[4] These principles were enunciated by Mendel in a paper entitled, "*Versuche über Pflanzenhybriden*" ("Researches on Plant Hybrids"), which appeared in the *Verhandlungen der naturforschenden Vereines in Brünn,* Vol. 4, 1865, *Abhandlungen,* pp. 3–47,[5] but escaped the attention of biologists until the year 1900, when by De Vries,[6] Correns[7] and von Tschermak,[8] they were independently and almost simultaneously rediscovered.[9]

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[1] Castle, W. E., *Proceedings American Academy of Arts and Sciences,* Vol. 38, 1903, p. 535.

[2] Biffin, R. H., *Journal Agricultural Science,* Vol. 1, 1905, p. 1.

[3] Weldon, W. F. R., *Biometrika,* Vol. 1, 1901, p. 228.

[4] De Vries, H., "Species and Varieties," Chicago, 1905, p. 716.

[5] Reprinted in *Flora,* Vol. 89, 1901, pp. 364–403.

[6] De Vries, H., "Das Spaltungsgesetz der Bastarde," *Berichte der deutschen botanischen Gesellschaft,* Vol. 18, 1900, pp. 83–90.

[7] Correns, C., "G. Mendels Regel über das Verhalten der Nachkommenschaft der Rassenbastarde," *Berichte der deutschen botanischen Gesellschaft,* Vol. 18, 1900, pp. 158–168.

Mendel's principles have been rephrased by later writers, and they are now usually referred to as the Law of Dominance, the Law of Segregation, and the Law of Recombination, respectively.

I. The Law of Dominance[10]

This so-called law is derived from the following principle of Mendel ("Versuche," etc., pp. 10–11):

> In der weiteren Besprechung werden jene Merkmale, welche ganz oder fast unverändert in die Hybride-Verbindung übergehen, somit selbst die Hybriden-Merkmale repräsentiren, als *dominierende,* und jene, welche in der Verbindung latent werden, als *recessive* bezeichnet.

Translated this principle reads:

> Those characters which pass entirely or almost entirely unchanged into the hybrid combination and consequently in themselves represent the characters of the hybrid, are designated as *dominant,* and those which become latent in the combination are termed *recessive.*

Since dominance is rarely absolute this principle is not general and should not be termed a law; indeed Mendel did not claim it as a law. Recent statements of the "Law of Dominance" may be thus summarized:

> When the two parents differ in respect of two contrasted characters, only one, the dominant character, will appear in the hybrid. Dominance, however, is seldom perfect, so that the dominant character in a hybrid seldom reaches as full expression as in the dominant parent.

II. The Law of Segregation.

Mendel's second principle ("Versuche," etc., p. 17) is thus stated:

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[8] Von Tschermak, E., "Ueber künstliche Kreuzung bei *Pisum sativum,*" *Zeitschrift für das landwirtschaftliche Versuchswesen in Oesterreich,* Vol. 3, 1900, pp. 465–555.

[9] De Vries's paper was received for publication on March 14, 1900, and that of Correns on April 24, 1900. Tschermak, in a postscript to his communication, says: "Die gleichzeitige Entdeckung Mendels durch Correns, de Vries (*Berichte der deutschen botanischen Gesellschaft,* 1900) und mich erscheint mir besonders erfreulich."

[10] "Man hat dieses die 'Prävalenz-Regel' genannt," Correns, C., "Uber Vererbungsgesetze," *Verhandlungen der Gesellschaft deutscher Naturforscher und Arzte,* 77 Versammlung, 1905, Part I, Leipzig 1906, p. 207.

> Da die Glieder der ersten Generation unmittelbar aus den Samen der Hybriden hervorgehen, wird es nun ersichtlich, dass die Hybriden je zweier differirender Merkmale Samen bilden, von denen die eine Hälfte wieder die Hybridform entwickelt, während die andere Pflanzen gibt, welche constant bleiben, und zu gleichen Theilen den dominirenden und recessiven Character erhalten.

This may be translated as follows:

> Since the members of the first generation[11] arise directly from the seeds of the hybrids, it is now evident that hybrids, for each pair of differentiating characters, form seeds, one half of which develops again the hybrid form, while the other half produces plants which remain constant and in equal proportions receive the dominant and recessive characters.

Various terms have been applied to this law by different authors, *e. g.*, ''Law of Disjunction,''[12] ''Law of Purity of Germ Cells,''[13] ''Law of Separation of Characters in Crosses,''[14] and ''Law of Dichotomy.''[15] Generalized, the law may be stated in the following form:

> In self-fertilized species an individual which is a hybrid with reference to a particular pair of characters tends to produce progeny one fourth of which is of pure race like one of the parents of the hybrid, another fourth of pure race like the other parent, while the remaining half is hybrid, like the original hybrid itself,"[16] that is, " from the inbred heterozygote come dominants and recessives in the proportion of 3 : 1, and only one dominant in three is pure, the other two being heterozygote.[17]

The above statement is purely objective;[18] it states the results of a cause, but gives no hint of that cause. It is not strange, therefore, that the modern statement of this law should have gravitated backward toward the fundamental cause underlying the law. The more usual statement of it at the present time is an inference from the facts observed, and may be stated as follows:

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[11] This is the F_2 generation of current literature.

[12] De Vries, H., *Comptes rendus de l'académie des sciences*, Paris, Vol. 130, 1900, pp. 845–847.

[13] Castle, W. E., *Proceedings American Academy of Arts and Sciences*, Vol. 38, 1903, p. 537.

[14] De Vries, H., *Journal Royal Horticultural Society*, Vol. 25, 1901, p. 243.

[15] Davenport, C. B., *Biological Bulletin*, Vol. 2, 1901, p. 307.

[16] Spillman, W. J., ''Application of Some of the Principles of Heredity to Plant Breeding,'' Bulletin No. 165, Bureau of Plant Industry, U. S. Dept. Agriculture, 1909, p. 9.

[17] Punnett, R. C., ''Mendelism.'' Cambridge, 1907, p. 23.

[18] For this paragraph and the one immediately following, the writer is indebted to Professor W. J. Spillman.

> When an individual is heterozygous for a given character it produces two kinds of gametes with reference to that character, one like those of one of its parents and the other like those of the other parent.

Mendel himself gives the corresponding statement of the law of recombination; that is, he states the inference about the kinds of gametes a hybrid must produce, as inferred by the types of the resulting progeny.

The principle of segregation, closely approximated long prior to Mendel both by Goss[19] and by Sageret,[20] was clearly enunciated by Naudin,[21] but these writers did not formulate their results in terms of numerical ratios as did Mendel. Knight[22] and Gärtner[23] as well as Wichura,[24] Godron[25] and Vilmorin[26]

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[19] "In the summer of 1820, I deprived some blossoms of the *Prolific blue* of their stamens, and the next day applied the pollen of a *dwarf Pea*, and of which impregnation I obtained three pods of seeds. In the following spring, when these were opened, in order to sow the seed, I found, to my surprise, that the colour of the Peas, instead of being a deep blue, like their female parent was of a *yellowish white*, like the male. Towards the end of the summer I was equally surprised to find that these white seeds had produced some pods with all blue, some with all white, and many with both blue and white Peas in the same pod.

"Last spring, I separated all the blue Peas from the white, and sowed each colour in separate rows; and I now find that the blue produce only blue, while the white seeds yield some pods with all white, and some with both blue and white Peas intermixed."—Goss, John, "On the Variation in the Colour of Peas, occasioned by Cross Impregnation." In a letter to the Secretary. Read October 15, 1822. *Transactions of the Horticultural Society of London*, Vol. 5, 1824, pp. 234–235.

[20] "Ainsi donc, en définitive il m'a paru qu'en général la ressemblance de l'hybride à ses deux ascendans consistait, non dans une fusion intime des divers caractèrs propres à chacun d'eux en particulier, mais bien plutôt dans une distribution, soit égale, soit inégale, de ces mêmes caractères: je dis égale ou inégale, parce qu'elle est bien loin d'être la même dans tous les individus hybrides provenant d'un même origine, et il y a entre eux, une très grande diversité."—Sageret, A., "Considérations sur la production des hybrides, des variantes et des variétés, en général, et sur celles de la famille des Cucurbitacées en particulier." *Annales des sciences naturelles*, Vol. 8, 1826, p. 302.

[21] "Tous ces faits vont s'expliquer naturellement par la disjonction de deux essences specifiques dans le pollen et les ovules de l'hybride."

''Supposons, dans la Linaire hybride (*L. vulgaris* × *L. purpurea*) de première génération, que la disjonction se soit faite à la fois dans l'anthere et dans le contenu de l'ovaire; que des grains de pollen appartiennent totalement à l'espèce du père, d'autres totalement a l'espèce de la mère; que dans d'autres grains la disjonction soit nulle ou seulement commencée; admettons encore que les ovules soient, au même degré, disjoints dans le sens du père et dans le sens de la mère; qu'arriverat-il lorsque les tubes polliniques descendront dans l'ovaire et vont chercher les ovules pour les féconder? Si le tube d'un grain de pollen, revenue à l'espèce du père, recontre un ovule disjoint dans le même sens, il se produira une fécondation parfaitement légitime, dont le resultat sera une plante entièrement retournée à l'espèce paternelle.''

Naudin, Ch., ''Nouvelles recherches sur l'hybridité dans les végétaux,'' *Nouvelles archives du muséum d'histoire naturelle de Paris,* Vol. 1, 1865, pp. 150, 153.

[22] ''Blossoms of a small white garden pea, in which the males had previously been destroyed, were impregnated with the farina of a large clay-coloured kind with purple blossoms. The produce of the seeds thus obtained were of a dark gray colour, but these having no fixed habits, were soon changed by cultivation into a numerous variety of a very large and extremely luxuriant white ones, which were not only much larger and more productive than the original white one, but the number of seeds in each pod were increased from seven to eight, to eight or nine, and not unfrequently, in one variety to ten. The newly made gray kinds I found were easily made white again by impregnating their blossoms with the farina of another white kind. In this experiment some of the seeds in the same pod would produce gray, and others white offspring, as occurs frequently in animals, which bring many young ones at birth, when the breeds of the male and female are of different colours.''

Knight, T. A., ''A Treatise on the Culture of the Apple and Pear, and on the Manufacture of Cider and Perry.'' Ludlow, 1801, pp. 37–38, footnote.

[23] ''Het allerduidelijkst evenwel is de invloed van het vreemde stuifmeel op de eitjes in dit opzigt bij de *Leguminosen,* wanneer b. v. de stempel van *Pisum sativum luteum* met het stuifmeel van *Pisum sativum viride* bestoven wordt, zoo ontstaan in deszelfs peulen zaadkorrels welke aan die der moeder gelijk zijn, doch andere van eene groene en nog andere van eene gevlekte, dat is, van eene groene en gele kleur. Deze zaadkorrels uit de eerste voortteling, zoowel de groene als de gele en de gevlkte, geven in de tweede voortteling peulen, die hetzelfde verschil, als die uit de eerste voortteling, opleveren.''

Gärtner, C. F., ''Beantwoording der Prysvraag over bastardeering,'' *Natuurkundige Verhandelingen van de Hollandsche Maatschappy der Wetenschappen te Haarlem,* Vol. 24, 1838, p. 52.

[24] Wichura, Max, ''Die Basterdbefruchtung im Pflanzenreich, erläutert an den Bastarden der Weiden,'' Breslau, 1865.

also seem to have come very near to the discovery of Mendel's principles.

III. THE LAW OF RECOMBINATION[27]

This law is based upon the following Mendelian principle ("Versuche," etc., p. 22):

> Die Nachkommen der Hybriden, in welchen mehrere wesentlich verschiedene Merkmale vereinigt sind, stellen die Glieder einer Combinationsreihe vor, in welchen die Entwicklungsreihen für je zwei differirende Merkmale verbunden sind.

This principle may be thus translated:

> The progeny of hybrids, in which several essentially different characters are combined represent the terms of a series of combinations, in which the development series for each pair of differentiating characters are united.

Spillman in his recent paper entitled "The Application of Some of the Principles of Heredity to Plant Breeding,"[28] thus concisely states this law:

> In the second generation of a hybrid there tends to occur every possible combination of the original parent characters.

This law was also discovered by Spillman independently in 1901 and announced provisionally by him in a paper read before the Association of American Agricultural College and Experiment Stations in November of that year.[29]

The clearest and most comprehensive account of Mendel's work extant is probably that of Bateson[30] in which may be found a full discussion of the doctrine of Mendelism together with a translation in English of Mendel's original papers. The French

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[25] Godron, D. A., "De l'espèce et des races dans les êtres organisés," 2d ed., Vol. 1, Paris, 1872, pp. 180–266.

[26] Vilmorin, H., "Note sur une expérience relative à l'étude de l'hérédité dans les végétaux," Paris, 1879, pp. 1–11. Extrait des mémoires de la société nationale d'agriculture de France—Année 1877.

[27] "Gesetz der Selbständigkeit der Merkmale," Correns, *l. c.*, p. 208.

[28] Bulletin No. 165, Bureau of Plant Industry, U. S. Dept. Agriculture, 1909, p. 22.

[29] Bulletin No. 115, Office of Experiment Stations, U. S. Dept. Agriculture, 1902, p. 88.

[30] Bateson, W., "Mendel's Principles of Heredity," Cambridge, 1909.

translation by Chappellier,[31] and also the recent works by Baur,[32] Haecker,[33] and Goldschmidt,[34] will be found very useful to the general student of Mendelism.

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THE RANGE OF SIZE IN THE VERTEBRATES

A SMALL shrew, *Microsorex winnemana,* recently described from Virginia by Preble, is said, if conclusions from but two specimens may be drawn, to be the smallest species of shrew and therefore the smallest mammal yet known from America.[1] These specimens measured 78 and 86 mm., respectively, in total length. *Microsorex hoyi* (Baird) of the eastern and central states averages from 82 to 88 mm. and *Sorex fontinalis* Hollister and *Sorex personatus* Geoffroy are but slightly larger. *Blarina parva* (Say) a short-tailed shrew, averaging in total length about 75 to 80 mm., is in this respect smaller than *M. winnemana,* but much larger in breadth, cranial and other characters. The smallest existing mammal is probably a minute *Crocidura* of the subgenus *Pachyura* from Madagascar.

The Insectivora, essentially an archaic and primitive group, reached its highest development in point of numerous and diverse adaptations in the Middle Eocene, from which there has been a gradual and steady decline. *Sorex* is known from the Middle Oligocene, *Talpa,* the mole from the Upper Oligocene and *Erinaceus,* the hedgehog from the Lower Miocene. These are some of the oldest of existing genera of mammals. The Malayan genus *Gymnura,* an Erinaceid, was said by Huxley[2] to possess the most generalized structure of all placental mammals. The persistence of the group is without doubt due in a large part to the small size and relative inconspicuousness of its members.

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[31] Chappellier, A., ''Recherches sur des hybrides végétaux (Traduction française). *Bulletin Scientifique de la France et de la Belgique,* Vol. 41, 1907, pp. 371–420.

[32] Baur, E., ''Einführung in die experimentelle Vererbungslehre,'' Berlin, 1911.

[33] Haecker, V., ''Allgemeine Vererbungslehre,'' Braunschweig, 1911.

[34] Goldschmidt, R., ''Einführung in die Vererbungswissenschaft,'' Leipzig, 1911.

[1] *Proc. Biol. Soc. Wash.,* Vol. 23, p. 101, 1910.

[2] *Proc. Zool. Soc. London,* p. 657, 1880.